Wide Bandgap Semiconductor Technology Initiative

Briefing to Industry

Dr. Edgar J. Martinez

DARPA/MTO

Wide Bandgap Semiconductor Technology Initiative Day

Agenda

Wednesday

7:00 – 8:30	**Registration and Continental Breakfast (Ballroom Foyer)**		
8:30 – 8:45	**Welcome / Introduction**	Dr. Edgar J. Martinez Dr. Robert Leheny	DARPA/PM DARPA/MTO Director
8:45 – 9:30	**Wide Bandgap Semiconductor Technology Initiative and BAA Process**	Dr. Edgar Martinez	DARPA/PM
9:30 - 10:00	**Materials Technology**	Ms. Laura Rea	AFRL
10:00 - 10:30	**Break**		
10:30 – 11:00	**Device and Circuit Technology**	Dr. John Zolper	ONR
11:00 – 11:30	**Materials-Device Correlation Activities**	Mr. Thomas Jenkins	AFRL
11:30 – 12:00	**High Power Electronics Update**	Dr. Daniel Radack	IDA
12:00 – 1:30	**Lunch**		
1:30 – 2:00	**Semiconductor UV Optical Sources**	LTC John Carrano	DARPA/PM
2:00 – 2:30	**Break**		
2:30 – 4:30	**Questions and Answers**	Dr. Edgar J. Martinez	DARPA/PM
4:30	**Adjourn**		

Outline

- WBGS Technology Initiative Overview
- BAA 01-35 Objectives and Structure
- Thrust I: RF/Microwave/Mm-wave Technology Area
- Thrust II: High Power Conversion and Distribution Electronics
- BAA 01-35 Procurement Process

WBGS Technology Initiative Objectives

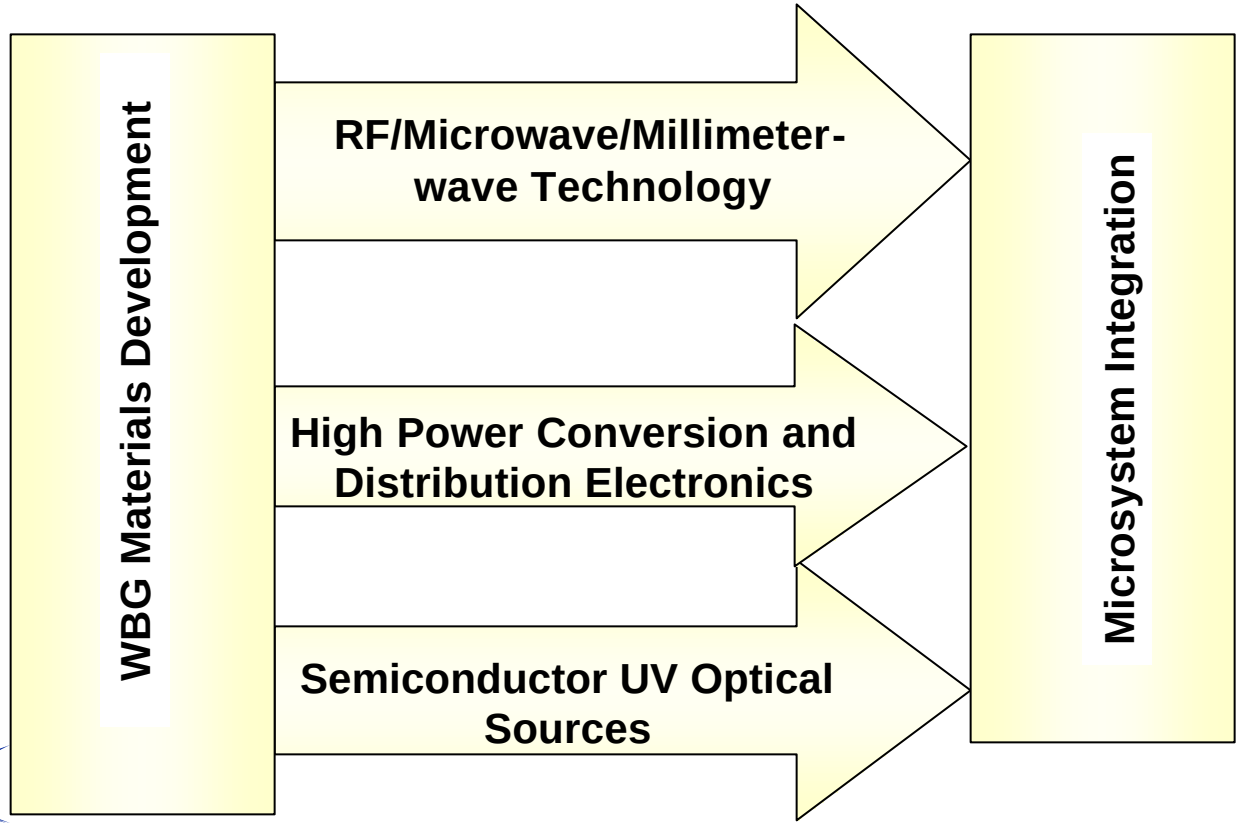
Enable revolutionary advances:

- **Radio Frequency (RF) systems**
- **Novel approaches for High Power Electrical (HPE) Control and Conversion**
- **New applications for UV optical sources**

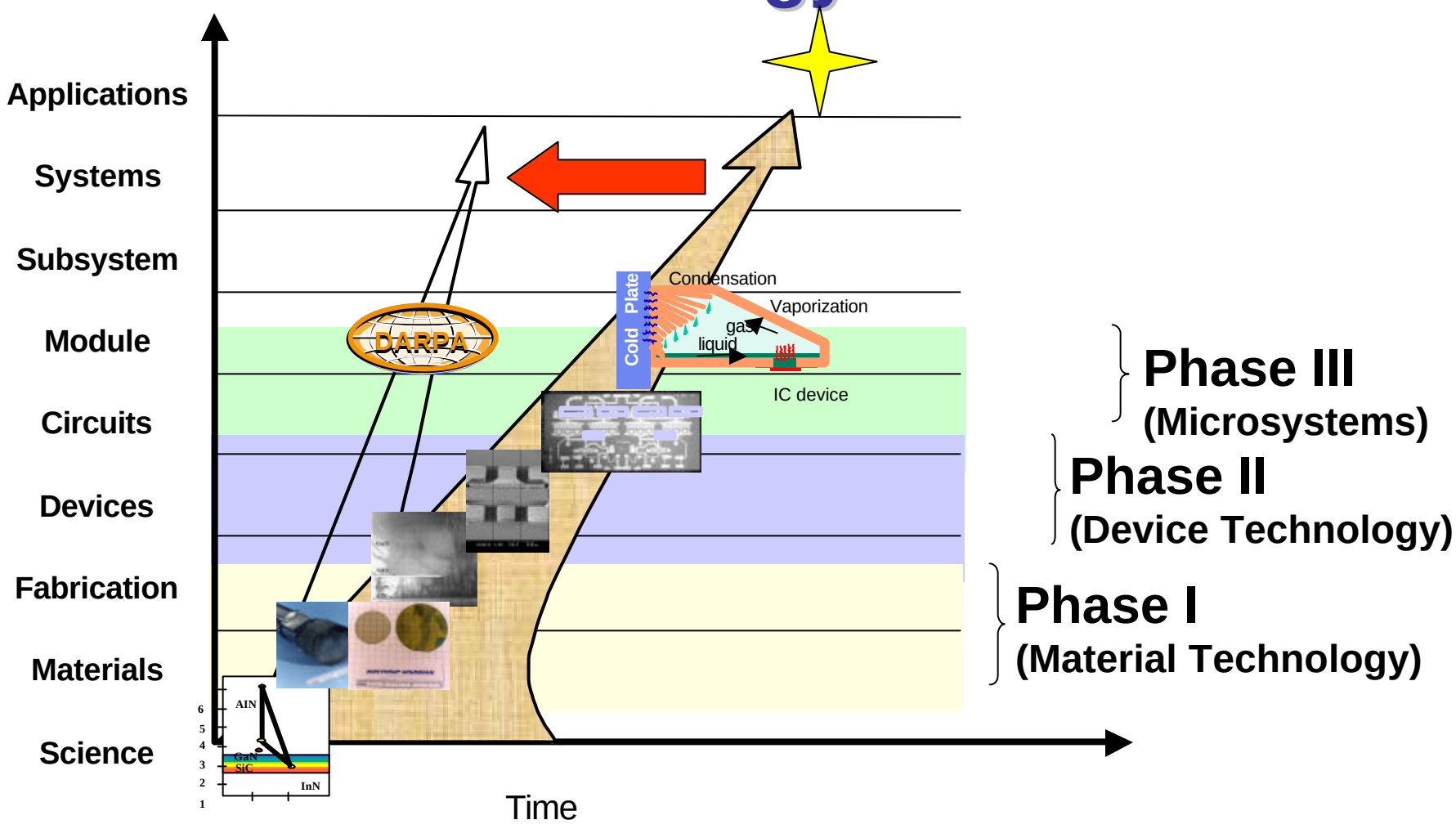
through the development and exploitation of the material, device, and circuit properties of Wide Bandgap Semiconductors (WBGS).

WBGS Technology Initiative Structure

Multi-disciplinary technology initiative cross-cutting 5 critical areas of WBGS R&D



WBGS Technology Innovation



DARPA's mission is to accelerate development while focusing on military relevant applications

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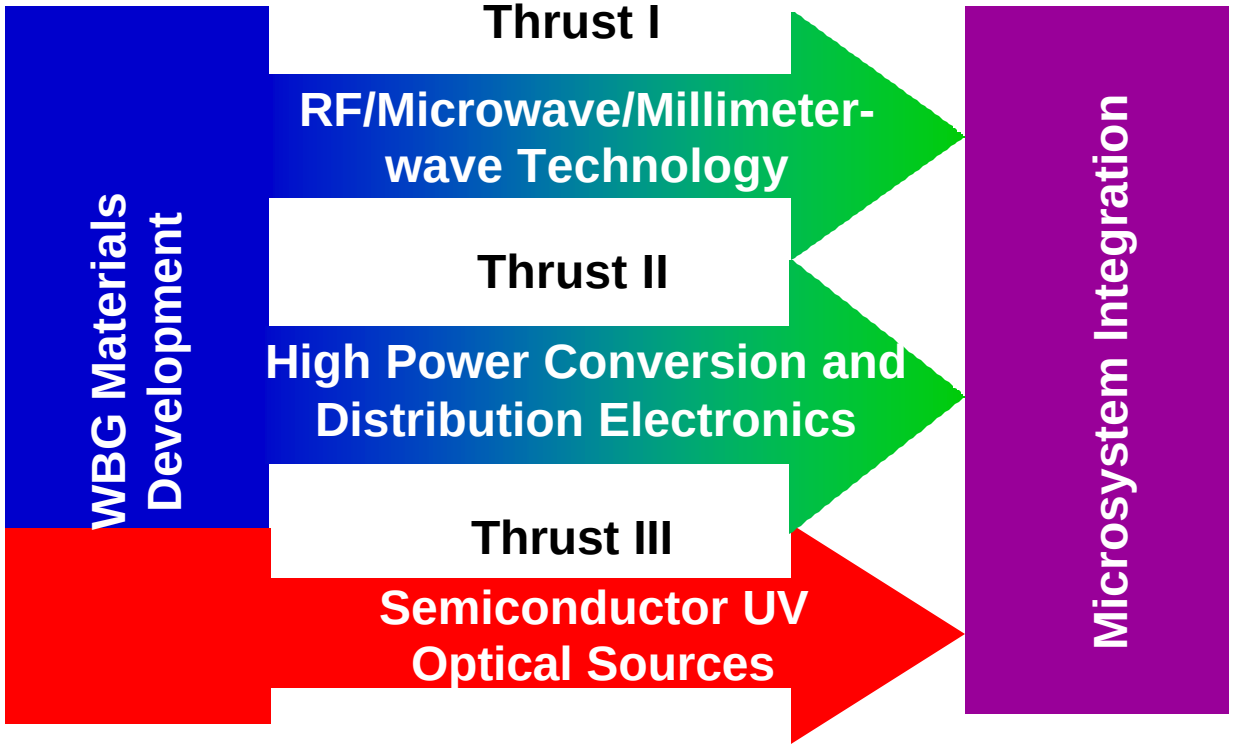
Wide Bandgap Semiconductor Technology Initiative
Research Opportunities

BAA01-35
24 month program



Phase I

Not included in BAA 01-35

BAA 01-35 Focus

Materials development in support of RF and HPE (Thrust areas I and II)

- **Substrate technologies**
  - Semi-insulating substrates (RF)
  - Large area, high quality substrates (RF, HPE)
- **Epitaxial technologies**
  - High uniformity (RF, HPE)
  - High growth rates (HPE, RF)
- **Fabrication**
  - Wafering (RF, HPE)
  - Oxidation (HPE)
  - Devices (RF, HPE)

Materials activities in support of the development of Opto-electronic devices will be pursued under a different Broad Agency Announcement

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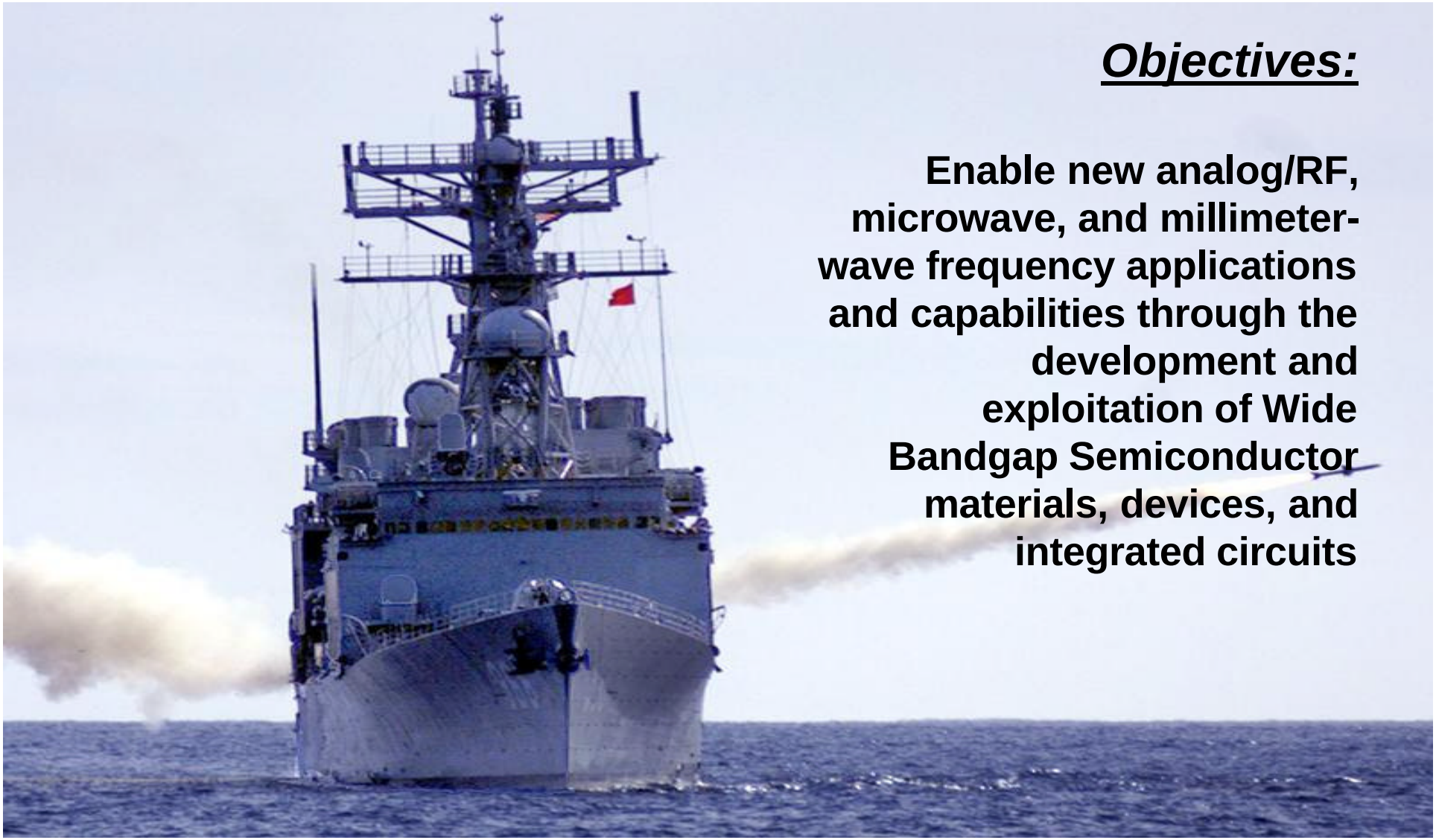
Thrust Area I:
RF/Microwave/Millimeter-wave Technology



Objectives:

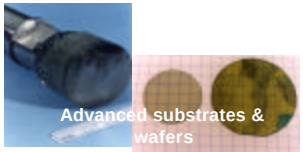
Enable new analog/RF, microwave, and millimeter-wave frequency applications and capabilities through the development and exploitation of Wide Bandgap Semiconductor materials, devices, and integrated circuits

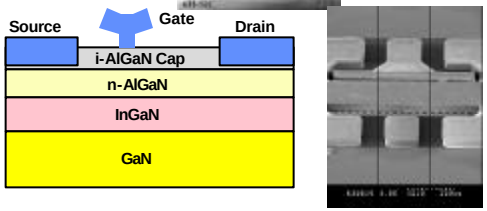
RF Thrust Organization

- **Phase 0 – Concept Study**
- **Phase I – WBGS Materials Development**
- **Phase II* – Device and Circuit Technologies**
- **Phase III* – MMIC Concurrent Engineering Demonstrations**

*** To be solicited through future BAAs**

Thrust I Goals



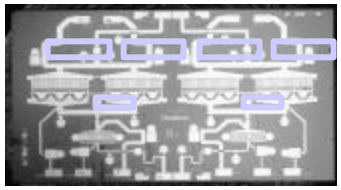


Material Technology

- Bulk Crystal
  - > 100 mm SI substrates
- Epitaxial Materials
  - Better than ± 1% composition, thickness, and doping control

Fabrication Technology

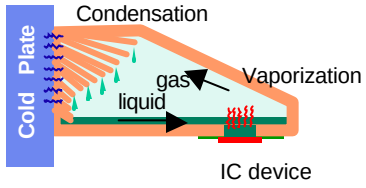
- High frequency
- large periphery devices
- microwaves and mm-waves



Devices and Integrated Circuits

Demonstration of:

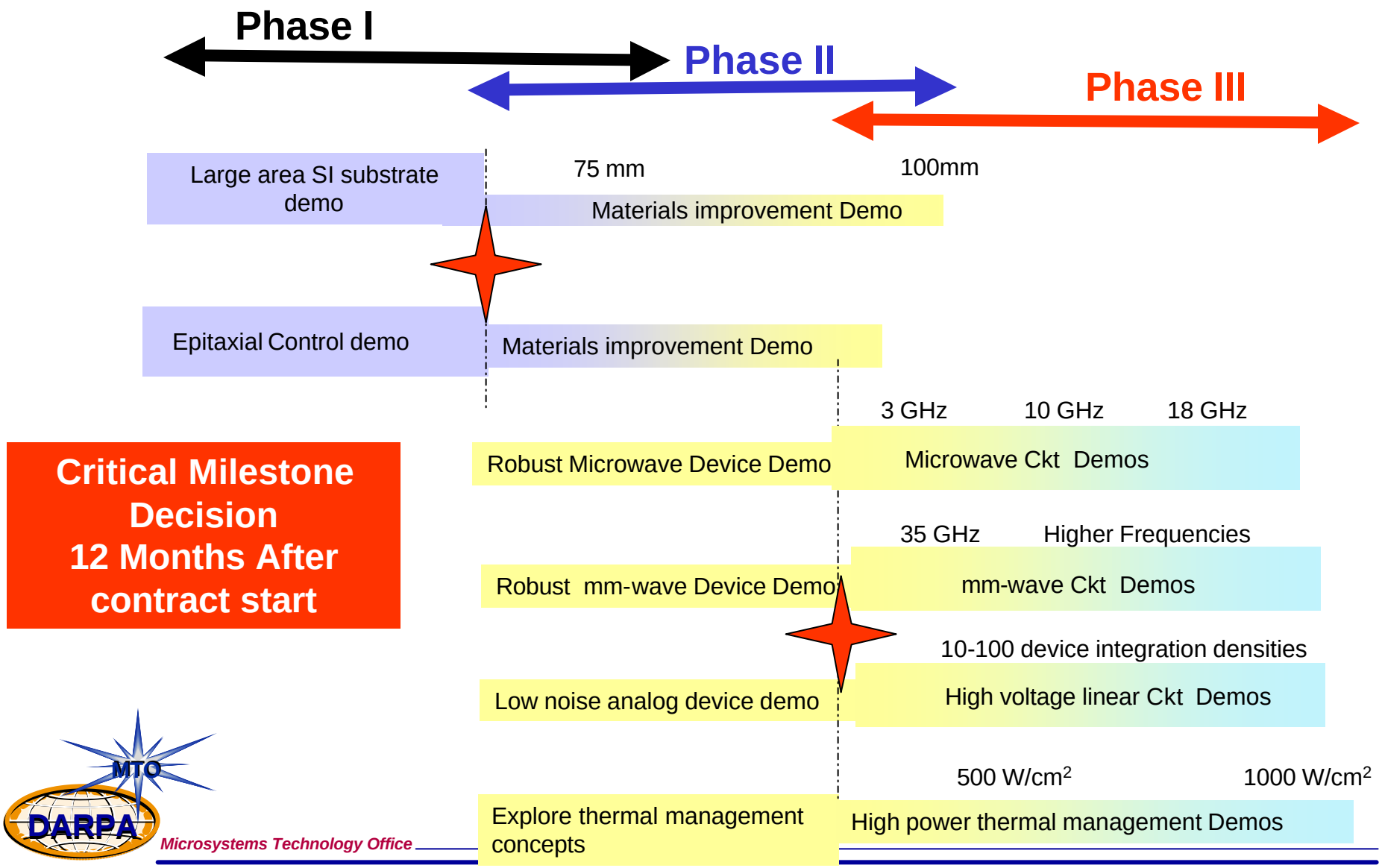
- Solid-state power amplifiers
- Low-noise amplifiers
- Linear analog ICs



High Power Electronic Integration

- > 1 KW/cm^2 thermal management techniques

Program Schedule



Critical Milestone Decision 12 Months After contract start

Phase 0: Concept Study

It is not essential that Phase I offerors submit a proposal for Phase 0, and conversely

- **Duration – Six months**
- **Deliverables - Final report**

Phase 0: Concept Study

(Six month initial effort)

- **System Study and Analysis**
  - **Identify potential applications for WBGS MMICs**
  - **Derive component requirements**
- **Technology Assessment**
  - **Derive device and material specifications**
  - **Identify current limitations and technical issues**
- **Assessment of Future Technology Development**
  - **Identify specific approaches to overcome current limitations**
  - **Identify critical experiments**
  - **Identify ancillary technologies to support the development of WBGS MMICs**

System Study and Analysis

- **Minimum of one military system area (radar, EW, communications, smart weapons, etc.)**
- **Potential component demonstration Phase III**
- **Prefer those that meet an identified DoD customer's vision and requirements**
- **Identify trade-off assessment (performance/system architecture/cost) among possible MMIC alternatives**

Examples of relevant information

- Quantitative operational performance enhancements or new capabilities (e.g. range, resolution, accuracy, data rate, etc.)
- Quantitative benefits (e.g. size, weight volume, cost, reliability, etc.)
- Impact on system architecture
- Identify windows of opportunity

Technology Assessments

- Specific requirements for substrates and epitaxial materials
- Device parameters and performance requirements
- Specific fabrication process issues
- Special test and evaluation tools and/or methodologies that need to be developed
- Packaging and thermal management requirements

Phase I: WBGS Materials Development In Support of RF Applications

Objectives:

Demonstrate revolutionary advances in materials, growth processes, and fabrication processes establishing a strong foundation for future efforts directed toward establishment of robust, mature processes for fabricating WBGS devices and ICs.

Duration – 24 months

Critical Milestones – 12 months after beginning of effort

Activities

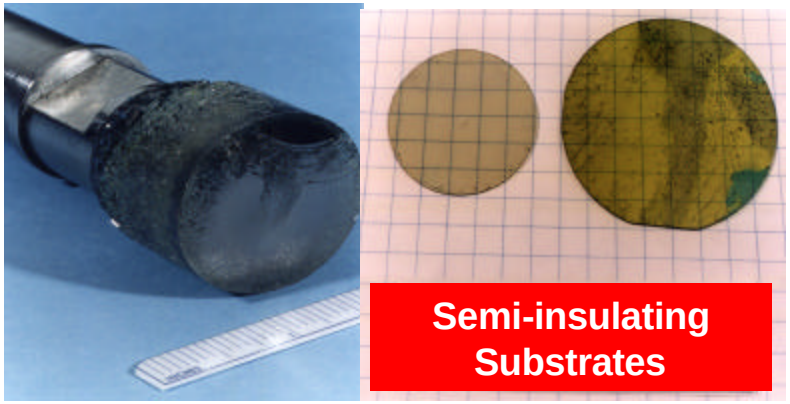
Task 1.1 Semi-insulating SiC Substrate Technology

Task 1.2 Alternative WBGS Substrate Technology

Task 1.3 Epitaxial Material Technologies

Task 1.4 Material-Device Correlations

Task 1.1: Semi-Insulating SiC Substrate Technology
Task 1.2: Alternative WBGS Substrate Technology



Program End Goals:

- Diameter > 100 mm (90 % useable area)
- Resistivity 10^5 ohms-cm @ 573 K
- Thermal Conductivity > 4W/cm-K
- Micropipe density < 1 /cm^2

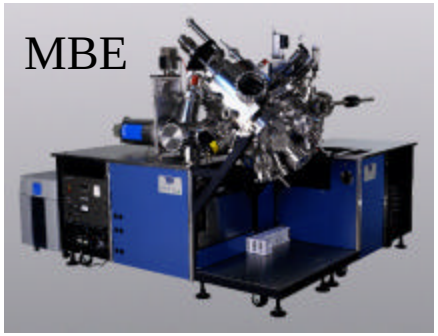
Technical sound approaches that will lead to reproducible and low cost to manufacture processes

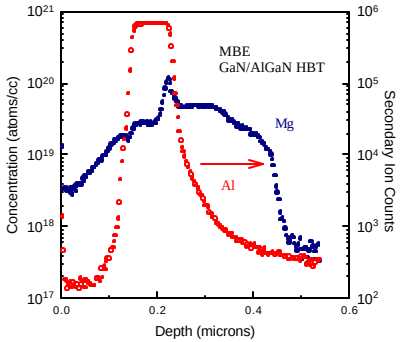
Areas of Interest

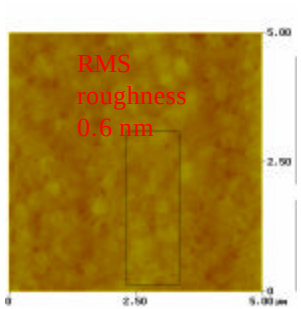
- Crystal growth science and techniques
- Growth process modeling and optimization
- Fabrication processes (wafering)
- Materials characterization

Collaboration with research groups interested in epitaxial material technology (Task 1.3) is highly encouraged

Task 1.3 Epitaxial Material Technology







Goals:

- **Innovative epi-processes that will result in better than ± 1% variation over large area substrates:**
  - **Thickness**
  - **Composition**
  - **Doping concentration**
- **Support devices operating at S-, X-, Ku, Ka-, and higher frequency bands**

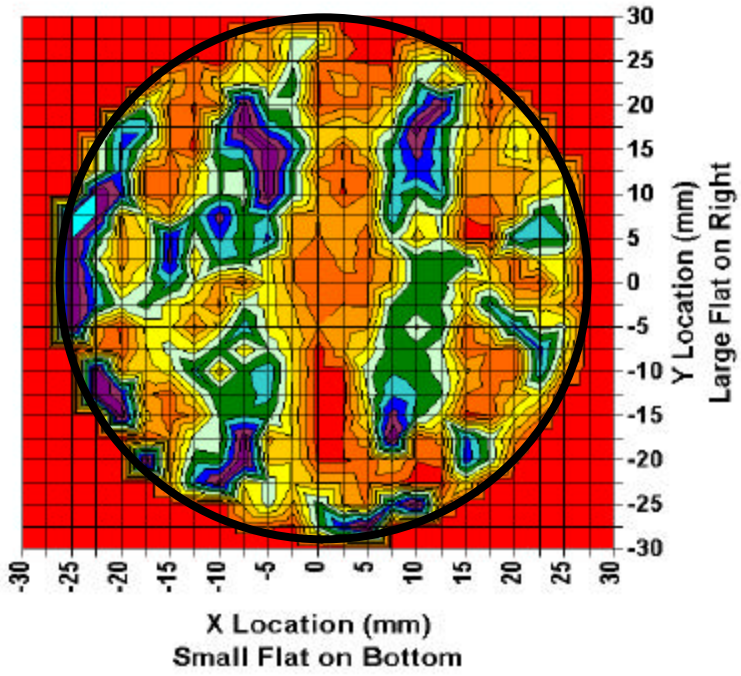
Technical sound approaches that will lead to reproducible and low cost to manufacture processes

Areas of Interest

- Crystal growth science and techniques
- Growth process modeling and optimization
- Fabrication processes (wafering)
- Materials characterization

Collaboration with research groups interested in substrate technology (Task 1.1 & 1.2) is highly encouraged

Task 1.4 Material-Device Correlation Activities



Goals:

- **Determine the suitability of device structures for different applications**
- **Determine the impact of improvements in material metrics on device performance**
- **Determine the appropriateness of the material uniformity for high yield processes**
- **Support devices operating at S-, X-, Ku, Ka-, and higher frequency bands**
  - **High output power**
  - **Low noise**
  - **Others**

What is included under this task

Proposers should provide details on how the following activities will be carried out

- **Establishment of a material-device correlation plan that will provide for exchange of information leading to improved materials for device applications**
- **Execution of the correlation plan (i.e. wafer-to-wafer, intra-wafer data analysis)**
- **Test reports summarizing progress**
- **Test, analysis and correlation data in electronic format**
- **Availability of materials and characterization devices for government laboratory test and evaluation**

What is not included under Task 1.4

- **Extensive device and IC fabrication process optimization efforts (Phase II)**
- **Application specific MMIC demonstrations (Phase III)**

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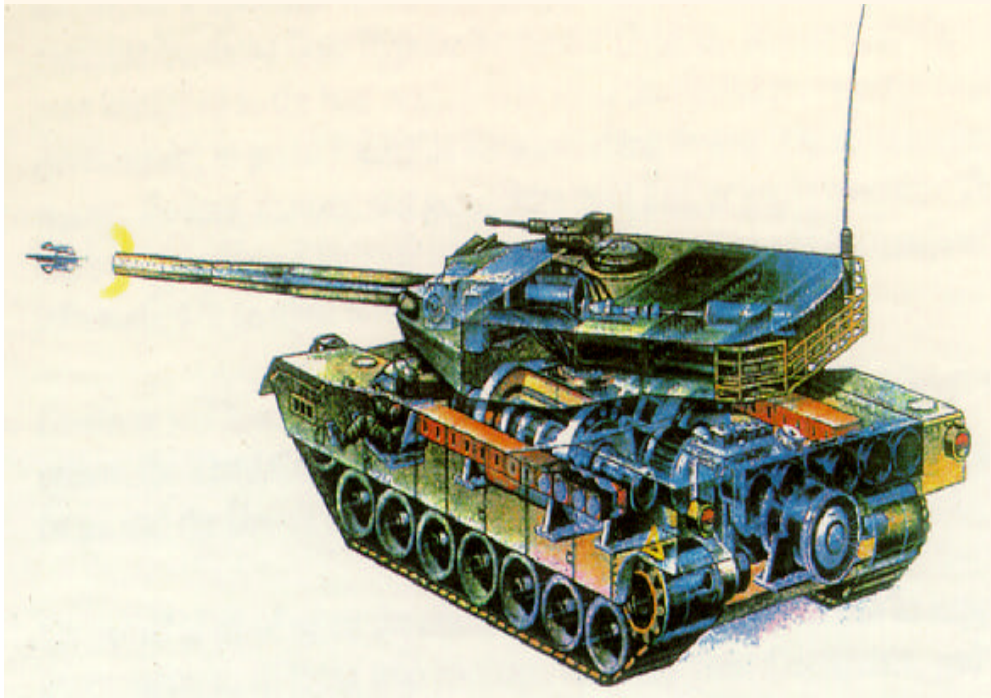
Thrust Area II
High Power Conversion and Distribution Electronics



All Electric Combat Vehicle (AECV)

Objectives:

Develop high power solid-state electronics in response to critical military needs for switching devices and integrated circuits that can meet the high-current, high-voltage, and speed requirements of electric components and sub-systems in emerging military applications.

Areas of Interest

- **High power semiconductor materials and processes (12-18 month efforts*)**
- **High power devices**
- **High power integrated circuit technologies**

*** Milestone demonstrating materials suitability will be required**

Task 1: High power semiconductor materials and processes

- Substrate technology
  - High quality (low defect) bulk starting materials
  - Surface preparation
- Epitaxial technology
  - High growth rates for thick layers
  - Low defects
  - Doping control and uniformity
- Processes
  - Oxidation
  - Doping activation

Task 2: High Power Devices

Device Performance Goals:

- **Power handling capabilities**
  - **Standoff voltages in the 10,000 V range**
  - **Conduction currents in the range of 1 KAmp**
  - **Power in the megawatt range**
- **Very low on-state resistance to minimize power dissipation in device**
- **Operating frequency > 150 KHz, high duty cycles**

Task 3: High Power Integrated Power Circuit Technologies

- **Electronic Integration for high-current, high voltage switches, control logic gates and passives**
  - **Monolithic or heterogeneously integrated in common substrate**
- **Intelligent high power controller ICs**
- **Thermal management**

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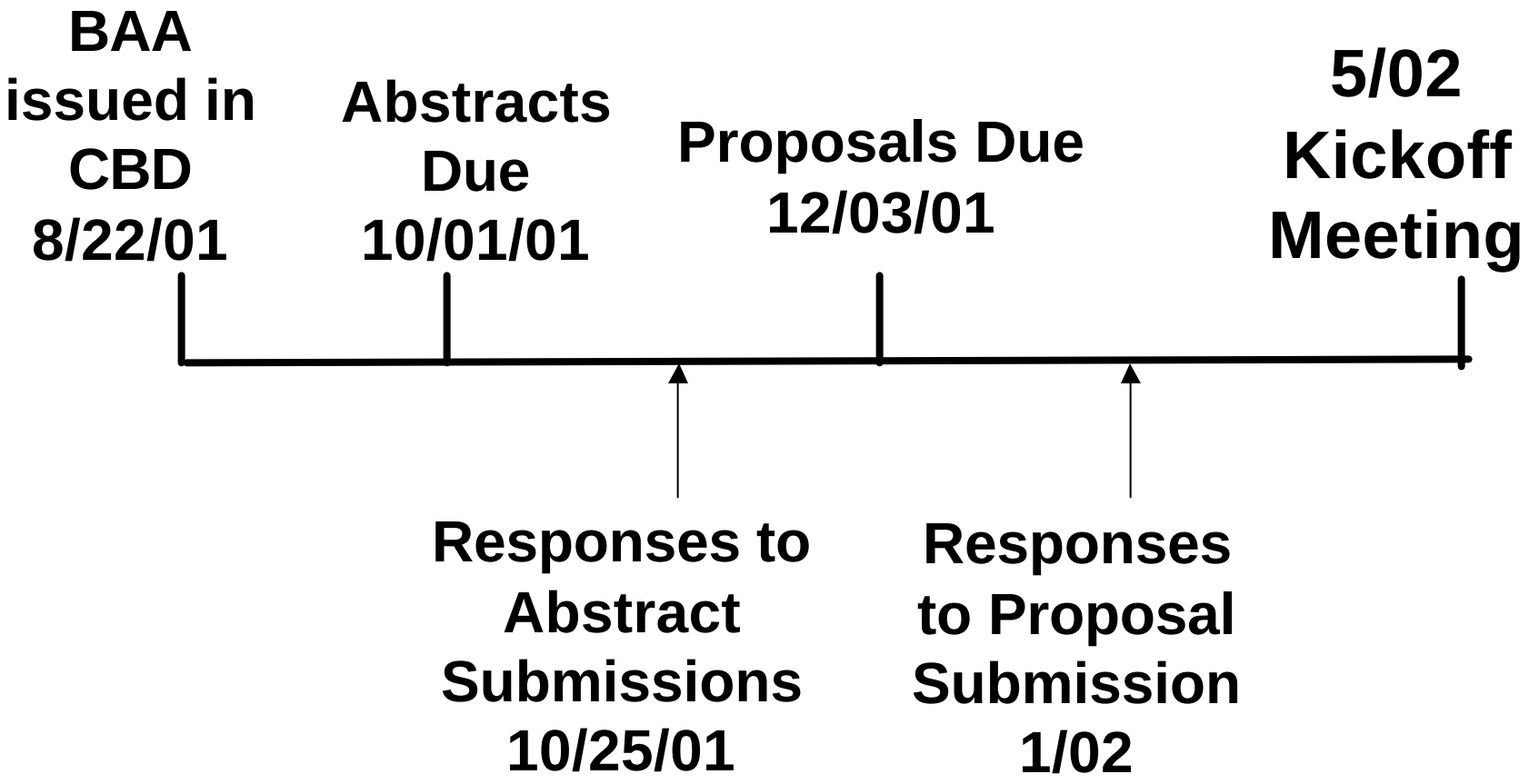
BAA01-35 Schedule*



*Does not include future BAAs

Wide Bandgap Semiconductor Technology Evaluation Criteria

- **Overall scientific and technical merit**
- **Potential contribution and relevance to the DARPA mission**
- **Plans and capability to accomplish technology transition**
- **Offeror's capabilities and related experience**
- **Cost realism**

Potential Contracting Vehicles and Types of Contracts

- **Procurement contract**
- **Grant**
- **Cooperative agreement**
- **Other transactions**

BAA 01-35
White Paper / Proposal Format

- **White Papers (Due October 1, 2001)**
  - Maximum 10 pages
  - ROM estimation
  - Summary of intentions
  - 15 copies required

- **Proposals (Due December 1, 2001)**
  - Maximum 50 pages
  - Cost estimate broken down by task and by year
  - Detail descriptions of proposed activities
  - 15 copies required